Protocol Development Summary (Last Upddate: 9/14/04)

Protocol: Air Chemistry - Ozone

Parks Where Protocol will be Implemented: ANTI, CATO, CHOH, GWMP, HAFE, MANA, NACE, PRWI, ROCR, and WOTR.

Justification/Issues being addressed:
Ozone damages human health, vegetation, and many common materials. It is also a key component of urban smog. Ozone threatens not only people with respiratory and pulmonary sensitivities (Gent, 2003), it also damages vegetation (Dizengremel 2001). The extent of such damage, even to ozone sensitive species (Skelly et al. 1999), is uncertain for NCRN landscapes because ozone exposure in plants (as in people) depends not just on the concentration, but on how active the plant is physiologically (Kurpius et al. 2002). What is certain is that this region experiences some of the highest ozone concentrations in the country and has been designated by the Environmental Protection Agency as a severe non-attainment area (EPA, National Ambient Air Quality Standards, NAAQS). Additionally, research has shown that vegetative damage thresholds are lower than the current regulatory thresholds, so that even areas that are in attainment with NAAQS may see ozone damage to plants, especially in humid regions where lack of drought stress allows plants to take up air (and ozone) more freely (Grunhage and Jager 1994, Panek and Goldstein 2001, Grunhage and Jager 2003). Thus, it is likely that ozone is causing damage to plants in the NCRN and that the damage increases with increasing concentrations (though not in a linear fashion). Monitoring concentrations, although only a partial solution, is the simplest way to begin to quantify trends in ozone damage. As models and data that can account for the microsite conditions that drive plant ozone uptake in the NCRN improve (e.g., Massman, 2004), it may be possible to use ozone concentrations and detailed GIS maps of the above microsite factors to calculate actual doses to plants. Until then, we will rely on ozone concentration as an indicator of ozone damage.

Specific Monitoring Questions and Objectives to be Addressed in the Protocol:

- When are visitors exposes to unhealthy air in NCRN parks (i.e., human health endpoints), and is this frequency increasing?
- When and for how long is vegetation exposed to unhealthy air in NCRN parks (i.e.,ecological endpoints), and is this exposure increasing?

The measurable objectives of the protocols are to:

1) Number of days in which the EPA ozone AQI is exceeded each year.
2) Overall concentration trends based on EPA trend analyses methods
3) Trends in SUM06 for the Midatlantic region

Basic Approach:
O_3 is measured by the Clean Air Status and Trends Network (CASTNet), Maryland department of Natural Resources, and the City of the District of Columbia. All these agencies use standard reference methods for the measurement of ozone, as designed by

the US EPA (http://www.epa.gov/ttn/amtic/criteria.html). A web-based clearinghouse for qualitative ozone data and forecasts can be found on the EPA airnow (www.epa.gov/airnow). Trends for overall Midatlantic region and for specific counties in the NCRN are also available at the EPA air trends website (www.epa.gov/airtrends). The I&M program will rely on data from this site for qualitative estimates of ozone trends, and obtain data (i.e., ozone concentrations, SUM06, and number of exceedance days) directly from these sites via download.

Since O_3 effects may impact plants at leaf, whole plant, and plant community scales, any significant trends in SUM06, should be related to trends in other vital signs for plant health, including plant community structure (especially any measures that involve the ozone sensitive species) and overall plant productivity. If the trends correlate, further research incorporating ozone biomarkers or bioindicator plants should be initiated to prove the linkage, so that appropriate management policies can be implemented where appropriate.

Principal Investigators and NPS Lead:
The NPS lead is Leland Tarnay, Air Quality Specialist, National Capital Region.

Development Schedule, Budget, and Expected Interim Products:
The focus of protocol development will be Standard Operating Procedures for accessing, archiving, and analyzing the necessary data. The draft SOP meeting NPS Guidelines (Oakley et al. 2003) is due by November 1, 2004.

Literature Cited:

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Gent, J. F., Triche, Elizabeth W., Holford, Theodore R., Belanger, Kathleen, Bracken, Micheal B., Beckett, William S., Leaderer, Brian P., 2003. Association of Low-Level Ozone and Fine Particles With Respiratory Symptoms in Children. Journal of the American Medical Association 290: 1859-1867.

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Oakley, K., L. Thomas, and S. Fancy. 2003. Guidelines for long-term monitoring protocols. Wildlife Society Bull. 31:1-3.

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Skelly, J. M., J. L. Innes, et al., 1999. Observation and confirmation of foliar ozone symtoms of native plant species of switzerland and southern Spain. Water, Air, and Soil Pollution 116: 227-234.

Protocol Development Summary (Last Update 9/8/04)

Protocol: Air Chemistry – Nitrogen/Sulfur Deposition.

Parks Where Protocol will be Implemented: ANTI, CATO, CHOH, GWMP, HAFE, MANA, NACE, PRWI, ROCR, and WOTR.

Justification/Issues being addressed:
The Chesapeake Bay Watershed (which includes the NCRN) receives some of the highest fluxes of N and S among the estuarine watersheds of the eastern seaboard (Lynch et al. 2000, Meyers et al. 2000, Sheeder et al. 2002). Deposition of S (10-14 kg S ha^{-1} yr^{-1}) and the associated hydrogen ion create "acid rain" have decreased markedly since the implementation of the Clean Air Act Amendments (CAAA) of 1990 (Lynch et al. 2000). Acidification in streams at Shenandoah NP to the west of the NCRN continues (Sullivan et al. 2003). Unlike SO_4^{2-}, NH_4^+ and NO_3^- deposition have not concomitantly decreased, and continue to cause both acidification in poorly buffered upland streams, and eutrophication at the bottom of watersheds. A substantial portion of the N deposited to the Chesapeake Bay Watershed (5-12 kg N ha^{-1} yr^{-1}) escapes to its estuary, where it causes toxic algal blooms and lowers the levels of dissolved oxygen that aquatic organisms require to breathe (Castro et al. 2001, Meyers et al. 2000). Upstream of the estuaries (i.e., parks like Catoctin Mountain Park and Prince William Forest Park), N deposition and eutrophication can affect plant community structure and cause leaching of important minerals from soils (Fenn et al. 2003). Wet deposited NO_3^- and NH_4^+, although an incomplete measure of total N deposition, will be used as an indicator N deposition trends. Combined with SO_4^{2-} wet deposition data, these numbers will also provide an indicator for acidification caused by atmospheric pollutants. Because N and S deposition can affect water quality parameters (i.e., nitrate, ammonia, and/or DON), soil characteristics (ion exchange characteristics), and encourage invasive plants (i.e., grasses through excess N), these parameters should be tracked along with the deposition numbers to ensure that any correlations and underlying linkages are quantified.

Specific Monitoring Questions and Objectives to be Addressed in the Protocol:

- Are nitrogen (N) and sulfur (S) deposition, as measured at NADP sites, increasing or decreasing?
- Are changes in N and S contributing to changes in water quality, soil characteristics, or invasive species?

The measurable objectives of the protocols are to:

1. Changes in seasonal SO_4^{2-} deposition (kg-SO_4^{2-} ha^{-1} yr^{-1})
2. Annual SO_4^{2-} deposition (kg-SO_4^{2-} ha^{-1} yr^{-1})
3. Changes in seasonal total wet N (NO_3^- + NH_4^+) deposition (kg-N ha^{-1} yr^{-1})
4. Annual wet N deposition (kg-N ha^{-1} yr^{-1})

Basic Approach:
Although there is only one National Atmospheric Deposition Program (NADP) site in the NCRN (MD07), other nearby sites can reasonably be assumed to represent the NCRN,

with allowances for orographic effects on precipitation (Sheeder et al. 2002). In the Chesapeake Bay Watershed, three sites lie in close proximity to the NCRN (VA28, WV18, and MD13; see http://nadp.sws.uiuc.edu/sites/), have been in place long enough to assess trends. As time passes, other sites (MD07, PA47, MD15, NJ00, MD08, and PA00) may also be included in the analysis.. Protocols for these measurements can be found at http://nadp.sws.uiuc.edu/QA/. (Lamb and Bowersox 2000, Lehman, 2004). All data is quality checked and assured, within the NADP quality assurance framework, then analyzed for trends as part of the NPS GPRA trends product (http://www2.nature.nps.gov/air/who/gpra). The NPS Air Resources Division (ARD) produces this analysis annually. If parks and/or the IM program have reason to believe that these general products do not represent their park, trends at individual sites should be investigated according to methods and criteria developed by the NADP program (Lamb and Bowersox 2000, Lehman, 2004).

Principal Investigators and NPS Lead:
The NPS lead is Leland Tarnay, Air Quality Specialist, National Capital Region.

Development Schedule, Budget, and Expected Interim Products:
The focus of protocol development will be Standard Operating Procedures for accessing, archiving, and analyzing the necessary data. The draft SOP meeting NPS Guidelines (Oakley et al. 2003) is due by November 1, 2004.

Literature Cited:

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Meyers, T. P., J. E. Sickles, et al., 2000. Atmospheric Deposition to Coastal Estuaries and Their Watersheds. In: Nitrogen Loading in Coastal Water Bodies, An Atmospheric Perspective. R. A. Valigura, R. B. Alexander, M. S. Castroet al (Eds.). Washington, D.C., American Geophysical Union. 57: 53-76.

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Sullivan, T. J., B. J. Cosby, et al., 2003. Assessment of Air Quality and Related Values in Shenandoah National Park. Washington DC, National Park Service.

Protocol Development Summary (Last Update: 9/14/04)

Protocol: Visibility

Parks Where Protocol will be Implemented: ANTI, CATO, CHOH, GWMP, HAFE, MANA, NACE, PRWI, ROCR, and WOTR.

Justification/Issues being addressed:
Atmospheric fine particles with diameter of less that 2.5 µm ($PM^{2.5}$) are known to be an important influence on the clarity of the atmosphere, due their light-scattering and light-absorbing properties (Malm et al. 1994, Finlayson-Pitts and Pitts 2000). Fine particles are also known to be a human health hazard, especially to active individuals (e.g., hikers and children; Romieu et al. 1996, Korrick et al. 1998, Pope 2000, Gent et al. 2003), and to people taking medication for asthma and other respiratory disorders (Romieu et al. 1996, Gent et al 2003). In the presence of ozone, all of these effects appear to be intensified (Romieu et al. 1996, Korrick et al. 1998, Gent et al. 2003).

Many of the precursors that create $PM^{2.5}$ in the NCRN are also precursors for O^3, and for the components of N and S deposition. Tracking all these and correlating their changes over the long-term will give land manager a better understanding of how the $PM^{2.5}$ that creates so much of the haze in this region correlates with other, less visible pollutants affect different parts of the ecosystem, as well as human health.

Basic Approach:
PM2.5 concentrations measured at the urban site in the NCR (Haines Point) are well correlated with those at more rural sites (i.e., Dolly Sods) to the west. This indicates that the Haines Point measurements can be taken to represent regional $PM^{2.5}$ trends in a relative sense, although Dolly Sods measurements were 25 to 200% lower for any given measurement (Solomon et al. 2004) on an absolute basis. In addition, a web-enabled camera (http://www2.nature.nps.gov/air/webcams/parks/nacccam/washcam.htm) was established at the Netherland Carillion (GWMP) in 2003 to track visibility of the Washington Monument. This "optical monitoring" can help validate the nephelometer and $PM^{2.5}$ measurements, identify the sensitivity of the NCR viewshed to particulate pollution, and provide a basis from which to model future visibility impairment or improvements for the region (http://vista.cira.colostate.edu/improve/Publications/SOPs/arssop.asp. Trends in number of days can been tracked using summaries generated by EPA-available on the Metropolitan Washington Council of Government (MWCOG) website. Trends in $PM^{2.5}$ can be tracked using the IMPROVE website for access to the Haines Point measurements (http://vista.cira.colostate.edu/improve/Data/GraphicViewer/Trends.htm),

In addition, pictures taken by the NCRN webcam are a particularly effective way of conveying to the public the consequences of air pollutants, and can provide interpreters with a visual means to show levels of otherwise unseen pollutants. This interpretive component could be an important feedback to link human parts of the ecosystem to other more conventional ecosystem components.

Specific Monitoring Questions and Associated Objectives to be Addressed in the Protocol:

- Are the number of days network parks fail to meet national air quality standards for particulate matter for human health increasing?
- How is visibility in parks changing over time?

The measurable objectives of the protocols are to:

1) $PM^{2.5}$ mass, measured at Haines point ($\mu g\ m^{-3}$, clearest days trends, haziest days trends)
2) Component composition trends (i.e., are organics, nitrates, or sulfates increasing or decreasing).
3) AQI (particle) exceedences as quantified by the MWCOG (tallied over the entire year, significance at interannual scales determined by EPA analysis).
4) Webcam photos taken during exceedence days extracted and archived as a visual check for visual range estimates and for other pollutant levels.

Principal Investigators and NPS Lead:
The NPS lead is Leland Tarnay, Air Quality Specialist, National Capital Region.

Development Schedule, Budget, and Expected Interim Products:
The focus of protocol development will be Standard Operating Procedures for accessing, archiving, and analyzing the necessary data. The draft SOP meeting NPS Guidelines (Oakley et al. 2003) is due by November 1, 2004.

<u>Literature Cited</u>:

Finlayson-Pitts, B. and J. J. Pitts, 2000. Chemistry of the upper and lower atmosphere. San Diego, California, Academic Press.

Gent, J. F., Triche, Elizabeth W., Holford, Theodore R., Belanger, Kathleen, Bracken, Micheal B., Beckett, William S., Leaderer, Brian P., 2003. Association of Low-Level Ozone and Fine Particles With Respiratory Symptoms in Children. Journal of the American Medical Association 290: 1859-1867.

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Malm, W. C., J. F. Sisler, et al., 1994. Spatial and Seasonal Trends in Particle Concentration and Optical Extinction in the United-States. Journal of Geophysical Research-Atmospheres 99(D1), 1347-1370.

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Pope, C. A., 2000. Epidemiology of fine particulate air pollution and human health: Biologic mechanisms and who's at risk? Environmental Health Perspectives 108, 713-723.

Romieu, I., F. Meneses, et al., 1996. Effects of air pollution on the respiratory health of asthmatic children living in Mexico City. American Journal of Respiratory and Critical Care Medicine 154: 300-307.

Solomon, P., T. Klamser-Williams, et al., 2004. Comparison of the STN and IMPROVE Networks for Mass and Selected Chemical Components (Preliminary Results). San Francisco, CA, State Air Monitoring Working Group.

Protocol Development Summary (Last Update 9/8/04)

Protocol: Air Chemistry - Mercury

Parks Where Protocol will be Implemented: ANTI, CATO, CHOH, GWMP, HAFE, MANA, NACE, PRWI, ROCR, and WOTR.

Justification/Issues being addressed:
Mercury is a persistent, toxic, and volatile heavy metal that is globally distributed via the atmosphere. While its elemental form (Hg^o), is relatively harmless at ambient concentrations, its derivative organic forms (e.g., MeHg) are potent neurotoxins that bioaccumulate in aquatic food webs, directly harming humans, animals, and the ecosystem structure on which both depend (Morel et al. 1998). Although watershed factors, as opposed to atmospheric deposition, can often dominate MeHg production (Mason et al. 2002), recent research has shown that freshly deposited atmospheric mercury is more likely to be converted to the toxic form (MeHg) than "old" mercury (Babiarz et al. 2003). Although the NCRN experiences some of the highest fluxes of atmospheric mercury in the US (Mason et al. 2000a; Mason et al. 2000b), this mercury appears to be largely retained in NCRN watersheds (Mason et al. 1999, Lawson et al. 2001), and fish tissue concentrations appear to be decoupled from atmospheric deposition as a result (Benoit et al. 1998, Mason et al. 1999). Although Benoit et al. (1998) implicate high sulfide (which inhibits methyl mercury production at high levels in substrate) as one reason for this decoupling, researchers are uncertain as to what watershed factors maintain this decoupled state. Until the factors controlling watershed-based methylation are better understood, it is prudent to concurrently track mercury deposition rates in the area and fish tissue concentrations as an indicator of the risk to the watershed from atmospherically deposited Hg. Simultaneous increases in atmospheric mercury deposition and fish tissues will be evidence of atmospheric contributions to NCRN methylation, while increases in only fish tissue concentrations may indicate that watershed factors are contributing NCRN mercury methylation.

Specific Monitoring Questions and Objectives to be Addressed in the Protocol:

- How is mercury deposition, as measured by the Mercury Deposition Network (MDN), changing over time?

- Can mercury trends be correlated with trends in mercury in fish tissue concentrations or other indicators that quantify non-atmospheric mercury methylation?

The measurable objectives of the protocols are to measure:

1. Annual wet deposition of mercury,(µg Hg m^{-2}) as measured at Arendtsville, PA (PA00) and Beltsville, MD (MD99).
2. Seasonal wet deposition of mercury,(µg Hg m^{-2}) as measured at Arendtsville, PA (PA00) and Beltsville, MD (MD99).
3. Fish tissue concentrations, calibrated to national standards (i.e., yellow perch) as developed in the USGS Environmental Mercury Mapping Modeling, and Analysis (EMMMA) database.

4. Other available EMMMA watershed parameters (TBA—EMMMA website and database are in beta-testing and development beginning in October, 2004)

Basic Approach:
The NCRN will rely on trends in MDN values at Arendtsville, Pennsylvania (PA00, since 2000) and Beltsville, Maryland (MD99, since 2004) to monitor the amounts of mercury in precipitation. Since most of the mercury in precipitation is the soluble, reactive form, MDN measurements are the best surrogate for the amount of reactive mercury available for methylation in watersheds from atmospheric sources. MDN protocols can be found at http://nadp.sws.uiuc.edu/mdn/ (Lindberg and Vermette 1995, Vermette et al. 1995, Welker and Vermette 1996). Currently, none of these MDN sites have been operating long enough to assess long-term trends, so trend analyses will be a product only after 2006-7 (Lehman, 2004).

Even when trends for atmospheric mercury sources can be tracking successfully, MDN-based indicators will not detect any changes in the non-atmospheric factors that influence methylation. Therefore the watershed-based factors and endpoints have to be tracked concurrently. The USGS Environmental Mercury Mapping Modeling, and Analysis is currently beta-testing a website that will facilitate just that sort of analysis, including modeled fish tissue values that we will use initially as our indicator of watershed-based methylation indicator in the NCRN.

Principal Investigators and NPS Lead:
The NPS leads are Leland Tarnay, NCRN air quality specialist and Doug Curtis, NCRN regional hydrologist.

Development Schedule, Budget, and Expected Interim Products:
The focus of protocol development will be Standard Operating Procedures for accessing, archiving, and synthesizing data specific to the NCRN. The draft SOP meeting NPS Guidelines (Oakley et al. 2003) is due by November 1, 2004.

Literature Cited:

Babiarz, C. L., J. P. Hurley, et al., 2003. A hypolimnetic mass balance of mercury from a dimictic lake: Results from the METAALICUS project. 107: 83-86.

Benoit, J. M., C. C. Gilmour, et al., 1998. Behavior of mercury in the Patuxent River Estuary. 40: 249-265.

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Mason, R. P., N. M. Lawson, et al., 1999. Mercury in the Chesapeake Bay. Marine Chemistry 65: 77-96.

_____, N. M. Lawson, et al., 2000a. Annual and seasonal trends in mercury deposition in Maryland. Atmospheric Environment 34: 1691-1701.

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Welker, M. and S. Vermette, 1996. Mercury Deposition Network: QA/QC Protocols. 89th Annual Meeting of the Air and Waste Management Association, Pittsburgh, PA, A&WMA.

Protocol Development Summary (Last Update: 9/15/04)

Protocol: Weather

Parks Where Protocol will be Implemented: ANTI, CATO, CHOH, HAFE, GWMP, MANA, MONO, NACE, PRWI, ROCR, and WOTR

Justification/Issues being addressed: Temperature and precipitation, taken over time scales of years, decades or longer, are the basic components of climate. Climate provides the physical constraints that determine plant and animal survival and drives the basic processes that underpin ecosystems. Current climate models predict substantial climate related changes climate of this region, and in the ecology as a result. These include (1) changes in forest species composition (i.e., loss of sugar maples in the north, encroachment of savannah in the south), (2) increased frequency of heavy precipitation events and flooding, and (2) an overall increase in the heat index of 8-20 degrees F (National Assessment Synthesis Team 2000).

Monitoring the basic components of climate will help to discern whether these predictions are accurate for the NCRN, and help managers to anticipate these changes in their management practices. For example, if the climate no longer supports sugar maples, management plans should allow for that. .

Specific Monitoring Questions and Objectives to be Addressed by the Protocol:

- Do climate trends (i.e., temp, precipitation) correlate with other network monitoring programs?
- Can any changes in vegetation or other biological components be attributed to changes in climate?
- To what extent does the urban heat island effect impact climate in the NCRN parks?

The measurable objectives of the protocols are to:

1. Determine long-term trends in average monthly maximum temperature, average monthly minimum temperature, average monthly mean temperature, and total monthly precipitation in NCRN parks that span the gradient between urban, suburban and rural systems.

Basic Approach: Monitoring is already being done in or near all parks in the NCRN. The data are currently managed by the National Oceanic and Air Administration (NOAA).

Principal Investigators and NPS Lead: NPS Lead - Marian Norris.

Development Schedule, Budget, and Expected Interim Products: Protocol development will consist primarily of writing a protocol that meets NPS standards (Oakley et al. 2003) and incorporates existing standard protocols. We will need to write new sections in the protocol narrative and SOPs to make the standard protocols specific to NCRN parks, such as describing nearest sampling locations and documenting how data will be entered into NPS computers, analyzed, and reported. Protocols will be submitted with the Phase III draft.

Literature Cited:

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Oakley, K., L. Thomas, and S. Fancy. 2003. Guidelines for long-term monitoring protocols. Wildlife Society Bull. 31:1-3.

Protocol Development Summary (Last Update: 8/11/04)

Protocol: Physical Habitat Index (PHI)

Parks Where Protocol will be Implemented: ANTI, CATO, CHOH, HAFE, GWMP, MANA, MONO, NACE, PRWI, ROCR, and WOTR

Justification/Issues being addressed: Physical habitat affects fish diversity more than water quality does (Gorman and Karr 1978). The PHI has been adapted by the Maryland Biological Stream Survey as a way to monitor physical habitat and can also be easily adapted to the NCRN parks. PHI describes the surrounding riparian components which provide important habitat wildlife and ecological services such as trapping sediment, modifying flood flows, and increasing groundwater recharge (Heinz Center 2002). The PHI also measures a variety of physical components including fish habitat structure, river depth, stream and floodplain vegetation composition, stream geomorphology, sediment accumulation, channel morphology, substrate quality, and riparian condition. In addition, a physical habitat index (PHI), can be used to identify non-point sources of pollution, determine the effects of local land-use on a stream or other body of water, and in determining these effects indicate how to remedy them (Petersen 1992).

Specific Monitoring Questions and Objectives to be Addressed by the Protocol: Some of the specific monitoring questions that will be addressed by this protocol include:

- In what way does the PHI correspond to changes in impervious surface in the watershed?
- In what way does the PHI correspond to changes in fish Index of Biological Integrity in the watershed.
- In what way does the PHI correspond to changes in aquatic macroinvertebrate abundance and density in the watershed.

The measurable objectives of the protocols are to:

(1) Determine annual changes in the Physical Habitat Index for selected streams.

Basic Approach: Adaptation of the Maryland Biological Stream Survey for NCRN parks to incorporate observations already made by the parks. It is strongly recommended that habitat observations be taken when any data is collected and accompanied by photo documentation of sites condition(s). To ensure data comparability MD-DNR's MBSS habitat observation field form will be used with some additions from EPA guidance (U.S. Environmental Protection Agency 1999) and NAWQA (see recommendations for rivers and streams at http://www.epa.gov/owow/monitoring/rbp).

Principal Investigators: Dr. Bob Hilderbrand (University of Maryland Center for Environmental Sciences, Cambridge, MD, 21613), Dr. Rich Raesly (Frostburg State University, Frostburg, MD, 21532), and Paul Kayzak (Maryland Dept. of Natural Resources, Annapolis, MD, 21401). NPS Lead: Marian Norris

Development Schedule, Budget, and Expected Interim Products: A Water Quality Pilot project began in 2004 and included the PHI. The protocols will be submitted as the project's final report in October 2004. This project used FY03 funds and cost $60,000.

Literature Cited:

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Protocol Development Summary (Last Update: 8/12/04)

Protocol: Surface Water Dynamics

Parks Where Protocol will be Implemented: ANTI, CATO, CHOH, HAFE, GWMP, MANA, MONO, NACE, PRWI, ROCR, and WOTR

Justification/Issues being addressed:
One of the more basic water resource components that can be influenced by human development is the flow regime of a stream. The most fundamental hydrological measurement that characterizes all stream ecosystems is discharge. Discharge is measured by the volume of water flowing through a cross section of a stream channel per unit time (flow X stream cross-section X stream stage). Discharge provides an indication of stream power or the ability of the river to do work. The work performed by the stream influences the distribution of suspended sediment, bed material, particulate organic matter, and other nutrients. The distribution of these materials has substantial influence on the distribution of riverine biota. In addition, discharge and stream power combine with other basin conditions to influence meander patterns and floodplain dynamics (Gore 1996) which are important in providing habitat for flora and fauna (Allan 1995).

An analysis of the manner in which discharge varies over time, or the hydrograph, provides insight into the characteristics of the watershed that influence such conditions as runoff and storage (Gore 1996). Examination of the shape of a daily hydrograph during a storm event can indicate the condition of the stream and its basin: infiltration capacity of the catchment, size of the basin, storage capacity, absorptive surface, and channel size (Gore 1996).

The intensity of the exposure to potential stressors for stream organisms depends on how fast that water is traveling past the organisms, and on the dilution factor, which depends on how much water is in the stream. Surface water dynamics data provides key "support" data for other vital signs indicators including freshwater quality, groundwater dynamics, stream threatened and endangered species and fish assemblages, threatened and endangered amphibians and reptiles, erosion and deposition, wetlands, and riparian habitat.

Specific Monitoring Questions and Objectives to be Addressed by the Protocol:

- What is the baseline spatio-temporal variation in surface water dynamics for NCRN parks?
- What are the long-term trends in surface water dynamics?
- How do surface water dynamics vary with associated vital signs?
- What is the influence of increasing impervious surfaces in the watershed upon hydrology?
- Is sufficient water available for ecological, recreational, and aesthetic purposes of the parks.
- What is the relationships between surface water dynamics and other NCRN vital signs such as aquatic threatened and endangered species.

The measurable objectives of the protocols are to:
(1) Determine flow, stage, and discharge of surface water in priority streams of the NCRN Parks.

with stream flow information that is required to comply with state mandates for water resource protection. The development of the NCRN stream gaging network provides a valuable linkage between National Capital Region parks and the national stream flow monitoring program.

Basic Approach: USGS will develop monitoring protocols including standard operating procedures as discussed by Oakley et al. (2003). USGS will also provide hands-on training to NCRN staff for taking flow readings in the field and data analysis. Protocols and SOP are being adapted from existing NPS and USGS protocols.

Stream flow will be measured at 24 sampling locations by handheld meters and existing USGS gauging stations. Flow measurements will be obtained monthly during the summer (in conjunction with station maintenance and downloading) with portable flow meters or current meters following the USGS standard protocol (Rantz 1982). Stage will be measured by water level loggers and stage gages. Water level monitors (pressure transducers) will be utilized as well at staff gauges or staff plates. Discharge-ratings curves and hydrographs will be developed for all sampling sites.

Principal Investigators and NPS Lead: USGS PI- Gary T. Fisher, Surface Water Quality Specialist , USGS Water Resources Division Maryland-Delaware-DC District Office, Baltimore, MD 21237. NPS Lead - Marian Norris,

Development Schedule, Budget, and Expected Interim Products: Protocols will be submitted with the Phase III draft. The PI will produce draft water quantity protocols and implementation plan by 1 December 2004, and deliver a final protocol document (4 paper copies plus 1 electronic copy) that addresses peer review comments no later than 1 June 2005. USGS (In kind contribution) expenditure of $8,644.00. NPS expenditure of $39,258.00, for a total cost of $47,902.00

<u>Literature Cited:</u>

Allan, J. D. 1995. Stream Ecology: Structure and Function of Running Waters. Chapman and Hall, New York.

Gore, J. A. 1996. Dishcarge Measurements and Streamflow Analysis. Pp.53-74, in Hauer, Richard and Gary A. Lamberti. 1996. Methods in Stream Ecology, New York, Academic Press.

Oakley, K., L. Thomas, and S. Fancy. 2003. Guidelines for long-term monitoring protocols. Wildlife Society Bull. 31:1-3.

Rantz, S. E. and others, 1982. Measurement and computation of streamflow: Volume 1. Measurement of stage and discharge. U.S. Geological Survey Water Supply Paper 2175.

Protocol Development Summary (Last Update 8/30/04)

Protocol: Water Chemistry

Parks Where Protocol will be Implemented: ANTI, CATO, CHOH, HAFE, GWMP, MANA, MONO, NACE, PRWI, ROCR, and WOTR.

Justification/Issues being addressed:
All NCRN parks contain one or more water bodies which drain into the Potomac River and ultimately into the Chesapeake Bay, both of which are of regional importance. Water chemistry is a major concern to the NCRN parks. It integrates many important ecological drivers and stressors, and can provide insights into ecological patterns and processes, including nutrient cycling, land use, soil erosion, air quality, vegetation communities, aquatic habitats, fish assemblages, and aquatic macroinvertebrates. Water chemistry parameters to be monitored in the NCRN include temperature, conductivity, pH, dissolved oxygen (DO), acid neutralizing capacity (ANC), nitrate, ammonia, DON, nitrite, and orthophosphate.

<u>Water temperature:</u> Temperature influences the density of water, the solubility of constituents (especially oxygen) in water, pH, specific conductance, the rate of chemical reactions, gas-diffusion rates, chemical-reaction rates, the settling velocity of particles, and biological activity in water (Radtke, Kurklin, and Wilde, 1998).

<u>Specific conductance (SC)</u>: SC is a function of the types and quantities of dissolved, electrically charged substances (ions) in water (Radtke, Davis, and Wilde, 1998). Collectively, all substances in solution exert osmotic pressure on the organisms living in it, which in turn adapt to the condition imposed upon the water by its dissolved constituents. With excessive salts in solution, osmotic pressure becomes so high that water may be drawn from gills and other delicate external organs resulting in cell damage or death of the organism. Some common sources of pollution that can affect specific conductance are deicing salts, dust reducing compounds, and the liming of agricultural fields (Stednick and Gilbert 1998).

<u>pH</u>: Changes in pH affect the dissociation of weak acids or bases, which in turn affects the toxicity of many compounds. For example, hydrogen cyanide toxicity to fish increases with lowered pH; rapid increases in pH increase NH_3 concentrations; and the solubilities of metal compounds are affected by pH. Also, in order to estimating the toxicity of ammonia, aluminum, and some other contaminants requires accurate pH values as metadata (MacDonald et. al. 1991).

<u>Dissolved Oxygen (DO)</u>: The presence and amount of DO in surface water determines the extent to which many chemical and biological reactions will occur. DO is vital to respiration of both plants and animals and is affected by numerous natural phenomena and human activities (Stednick and Gilbert 1998). Conditions that contribute to low DO levels include warm temperatures, low flows, water stagnation and shallow gradients (streams), organic matter inputs, and high respiration rates (MacDonald et al., 1991).

Acid Neutralizing Capacity (ANC): It is important to monitor for Acid Neutralizing Capacity (ANC) in the NCRN due to the threat from air pollution and acid rain.

Nutrient contamination: Nutrient contamination can cause changes in soil and ground water chemistry, reduced water quality, fishery health, and aquatic invertebrate communities and populations. High levels of nitrogen and phosphorous are a known problem due to fertilizer runoff in the Mid-Atlantic (EPA 2002). It is important to determine watershed nutrient export which is a critical ecosystem function in the greater Chesapeake Bay watershed where eutrophication is causing algal blooms and dead-zones. Phosphorus is singled out as an especially important indicator in the Heinz Center Report (2002) on the state of nation's ecosystems. .

Specific Monitoring Questions and Objectives to be Addressed by the Protocol:

- What is the baseline spatio-temporal variation in chemical conditions of surface waters in NCRN?
- How is the park's water chemistry changing relative to changes in regional water chemistry?
- How doe changes in water chemistry affect fish communities, aquatic macroinvertebrates, and stream channel morphology?
- Are NCRN waters meeting state water quality standards?
- Are management actions reducing pollutant loads?
- Is ANC sufficient for streams within the NCRN to withstand regional acidity inputs.

The measurable objectives of the protocols are to:

1. Determine long-term trends and natural variability in temperature, specific conductance, pH, dissolved oxygen, ANC, and nutrients of priority streams of the NCRN.

Basic Approach:
Monitoring protocols for the core water chemistry parameters (pH, DO, specific conductance, temp) and ANC are being adapted from existing USGS and NPS protocols. NCRN water quality monitoring efforts will be coordinated with ongoing monitoring efforts conducted by the parks and other state and local agencies. Where feasible, NCRN will augment existing activities and help with data analysis and interpretation.

Principal Investigators and NPS Lead: NPS Lead - Marian Norris

Development Schedule, Budget, and Expected Interim Products: Protocols are being developed by the NCR Aquatic Ecologist hired through funding from Water Reserouce Division (WRD). Draft protocols will be submitted with the Phase III draft for peer review.

Literature Cited

Heinz Center, The. 2002. The state of the nation's ecosystem. The H. John Heinz III Center for Science, Economics, and the Environment. Cambridge University Press.

MacDonald, L.H., Smart, A.W., and Wissmar, R.C. 1991. Monitoring guidelines to evaluate effects of forestry activities on streams in the Pacific Northwest and Alaska. U.S. EPA, Region 10. EPA 910/9-91-001. 155 p.

Radtke, D.B., Kurklin, J.K., and Wilde, F.D. 1998. Temperature, *in* Wilde, F.D., and Radtke, D.B., eds., Field measurements, *in* National field manual for the collection of water-quality data: U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chap. A6.1, 15 p.

Radtke, D.B., Davis, J.V., and Wilde, F.D. 1998. Specific electrical conductance, *in* Wilde, F.D., and Radtke, D.B., eds., 1998, Field measurements, *in* National field manual for the collection of water-quality data: U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chap. A6.3, 22 p.

Stednick, Dr. John D., and Gilbert, David M. 1998. Water Quality Inventory Protocol: Riverine Environments. National Park Service, Water Resources Division and Servicewide Inventory and Monitoring Program. Fort Collins, CO. Technical Report NPS/NRWRD/NRTR-98/177

Environmental Protection Agency (EPA). 2002. Mid-Atlantic Integrated Assessment (MAIA) Estuaries 1997-98 Summary Report: Environmental Conditions in the Mid-Atlantic Estuaries. USEPA, Office of Research and Development, National Health and Environmental Effects Research Laboratory, Atlantic Ecology Division (AED), Narragansett, RI 02882 and Region III, Philadelphia, PA 19103-2029. EPA/620/R-02/003. http://www.epa.gov/maia/html/estuary03.html Accessed 8/19/2004.

Protocol Development Summary (Last Update: 8/11/04)

Protocol: Macroinvertebrate Index of Biotic Integrity

Parks Where Protocol will be Implemented: ANTI, CATO, CHOH, HAFE, GWMP, MANA, MONO, NACE, PRWI, ROCR, and WOTR

Justification/Issues being addressed:
Aquatic macroinvertebrates are a significant, diverse biological and functional component of most eastern stream ecosystems. They are the food source for many other organisms in the ecosystem. The various species respond differently to different environmental stressors, are relatively easy to collect, and can be analyzed at many different levels of precision. Aaquatic macroinvertebrates, therefore, are an important tool to understand and detect changes in ecosystem integrity over time. Aquatic macroinvertebrate indices of biotic integrity can provide an assessment of the ecological ramifications of water quality and water quantity trends based on what organisms are present and what conditions these organisms require (Gerritsen 1995, Kerans and Karr 1994, Kerans and Karr 1992, Karr 1991). Biological data will be used in conjunction with water chemistry and physical habitat information to evaluate the overall condition of aquatic resources. This approach will be employed because impacts to water quality are so diverse and variable in duration that chemical monitoring alone may fail to detect many of them (Karr 1991, Karr 1981).

Specific Monitoring Questions and Objectives to be Addressed by the Protocol:

- What is the trend of aquatic macroinvertebrate species diversity and abundance?
- Are there anomalies in the diversity or abundance of aquatic macroinvertebrate communities in particular stream segments in NCRN parks that might suggest potential pollution sources?

The measurable objectives of the protocols are to:

(1) Detect trends in aquatic macroinvertebrate species diversity in priority streams of NCRN.

(2) Detect trends in aquatic macroinvertebrate species abundance in priority streams of NCRN.

(3) Detect stream impacts influencing trends in aquatic macroinvertebrate species diversity and abundance in priority streams of NCRN.

Basic Approach: The Macroinvertebrate IBI Protocols are an adaptation of the Maryland Biological Stream Survey for all NCRN parks including those in Virginia and the District of Columbia. Virginia streams are part of the Potomac River watershed and are sufficiently close that biological, chemical, and physical attributes will be comparable to streams in the existing MBSS sampling universe. This not only extends the monitoring program within the NCRN, but also puts NCRN sites within a regional context. Samples will be collected annually in summer (July – August).

Principal Investigators and NPS Lead: Dr. Bob Hilderbrand (University of Maryland Center for Environmental Sciences, Cambridge, MD, 21613), Dr. Rich Raesly (Frostburg State University, Frostburg, MD, 21532), and Paul Kayzak (Maryland Dept. of Natural Resources, Annapolis, MD, 21401). NPS Lead - Marian Norris.

Development Schedule, Budget, and Expected Interim Products: A Water Quality Pilot project began in 2004 and included the Macroinvertebrate IBI. The protocols will be submitted as the project's final report in October 2004. This project used FY03 funds and cost $60,000.

Literature Cited:

Gerritsen, J. 1995. Additive biological indices for resource management. Journal of the North American Benthological Society 14: 451-457.

Karr, J. R. 1991. Biological Integrity: a long-neglected aspect of water resource management. Ecological Applications 1: 66-84.

Karr, J. R. 1981. Assessment of biological integrity using fish communities. Fisheries 6:21-27.

Kerans, B. L. and J. R. Karr. 1994. A benthic index of biotic integrity (B-IBI for rivers of the Tennessee Valley. Ecological Applications 4:768-785.

Kerans, B. L. and J. R. Karr. 1992. Aquatic invertebrate assemblages: spatial and temporal differences among sampling protocols. Journal of the North American Benthological Society 119: 377-390.

Protocol Development Summary (Last Update: 8/11/04)

Protocol: Fish Index of Biological Integrity

Parks Where Protocol will be Implemented: ANTI, CATO, CHOH, HAFE, GWMP, MANA, MONO, NACE, PRWI, ROCR, and WOTR

Justification/Issues being addressed:
Fish constitute a significant, diverse biological and functional component of the river ecosystem. Trends in fish diversity may serve as a useful indicator of shifts in the condition of a stream ecosystem as it responds to anthropogenic actions. A survey of the biological components (fish, herps, macroinvertebrates, plankton, and vegetation) such as an Index of Biotic Integrity (IBI) determines how healthy the environment is based on what organisms are present and what conditions these organisms require (Gerritsen 1995, Kerans and Karr 1994, Kerans and Karr 1992, Karr 1991). Biological data will be used in conjunction with water chemistry and physical habitat information to evaluate the overall condition of aquatic resources. This approach will be employed because impacts to water quality are so diverse and variable in duration that chemical monitoring alone may fail to detect many of them (Karr 1991, Karr 1981).

Specific Monitoring Questions and Objectives to be Addressed by the Protocol:

- What is the trend of fish species diversity and abundance?
- Are there anomalies in the diversity or abundance of fish communities in particular stream segments in NCRN parks that might suggest potential pollution sources?

The measurable objectives of the protocols are to:

(1) Detect trends in fish species diversity in priority streams of NCRN.
(2) Detect trends in fish species abundance in priority streams of NCRN.
(3) Detect stream impacts influencing trends in fish species diversity and abundance in priority streams of NCRN.

Basic Approach: The Fish IBI Protocols are an adaptation of the Maryland Biological Stream Survey for all NCRN parks including those in Virginia and the District of Columbia. Virginia streams are part of the Potomac River watershed and are sufficiently close that biological, chemical, and physical attributes will be comparable to streams in the existing MBSS sampling universe. This not only extends the monitoring program within the NCR, but also puts NCR sites within a regional context. Sampling will be carried out by electroshocking. Samples will be collected annually in summer (July – August). If sampling occurs as little as once per year, data analysis must consider changes in the components to the index and not just the final score.

Principal Investigators: Dr. Bob Hilderbrand (University of Maryland Center for Environmental Sciences, Cambridge, MD, 21613), Dr. Rich Raesly (Frostburg State

University, Frostburg, MD, 21532), and Paul Kayzak (Maryland Dept. of Natural Resources, Annapolis, MD, 21401). NPS Lead - Marian Norris

Development Schedule, Budget, and Expected Interim Products: A Water Quality Pilot project began in 2004 and included the Fish IBI. The protocols will be submitted as the project's final report in October 2004. This project used FY03 funds and cost $60,000.

Literature Cited:

Gerritsen, J. 1995. Additive biological indices for resource management. Journal of the North American Benthological Society 14: 451-457.

Karr, J. R. 1991. Biological Integrity: a long-neglected aspect of water resource management. Ecological Applications 1: 66-84.

Karr, J. R. 1981. Assessment of biological integrity using fish communities. Fisheries 6:21-27.

Kerans, B. L. and J. R. Karr. 1994. A benthic index of biotic integrity (B-IBI for rivers of the Tennessee Valley. Ecological Applications 4: 768-785.

Kerans, B. L. and J. R. Karr. 1992. Aquatic invertebrate assemblages: spatial and temporal differences among sampling protocols. Journal of the North American Benthological Society 119: 377-390.

Protocol Development Summary (Last Update: 8/11/04)

Protocol: Forest Health Monitoring

Parks Where Protocol will be Implemented: ANTI, CATO, CHOH, GWMP, HAFE, MANA, NACE, PRWI, ROCR, and WOTR

Justification/Issues being addressed:
A variety of factors affect vegetation composition in the NCRN parks. Ecological factors include soils and geology, rain patterns, and nutrient availability. Anthropogenic stressors include air pollution, loss of habitat due to development (inside and outside of parks), erosion, and visitor use. The most significant threats, however, are recognized as exotic and invasive species (Cohn 2004, NPS and TNC 2001, NPS 1999) and white-tailed deer (Bates, pers. comm.).

In this region, invasive plants are reducing the indigenous biological diversity of the parks, degrading natural landscapes, and disrupting natural ecological processes at many levels. The known ecological impacts of invasive plants are immense and include loss of threatened and endangered species, altered structure and composition of vegetation communities, and reduction in plant species diversity. In addition, alteration of ecosystem processes occurs, such as the disruption of natural succession, prevention of seedling establishment of native plants, disruption of insect-native plant associations, alteration of natural fire regimes, hybridization with native plant species resulting in altered genomes, and introduction of reservoirs for harmful plant pathogens (NPS 1999, Randall and Marinelli 1996, NPS and TNC 2001).

Vegetation community changes are also apparent because of growing deer populations in the NCRN parks. Preliminary results of the NCRN deer density monitoring program indicate that deer in NCR parks range from 12 deer/km^2 (PRWI) to 38 deer/km^2 (CATO). Deer prefer some species over others which is changing the composition of native vegetation. For example, anecdotal evidence suggests that there has been no seedling regeneration in some areas of CATO in approximately 15 years. Monitoring the effects of deer will provide critical information to park managers.

FHM will provide park managers with comprehensive long-term data about the status of the parks' vegetation resources including the effects of ecological and anthropogenic stressors. Permanent plots will be used to provide basic information on status and trends of forest composition and structure. Data will be collected on native and non-native species frequency and abundance. Specific measures will be taken to asses the effects of deer browse. Additional vital signs will also be used to address the rate of spread of invasive species and will alert park managers of potential or new infestations (see Protocols: Occurrence of Selected Invasive Plant Species for details.

Specific Monitoring Questions and Objectives to be Addressed in the Protocol:

The measurable objectives of the protocols are to:

1. Determine status and trends in forest composition and structure for the natural areas of NCRN.
2. Determine the effects of white-tailed deer browsing on the vegetation composition and structure of vegetation communities of the NCRN.
3. Determine long-term changes in percent cover of native and non native herbaceous species and woody vines in natural vegetation communities in NCRN.
4. Determine change in native shrub and tree species stem density and abundance and the density and abundance of targeted exotic invasive shrubs and trees.

Basic Approach:
The protocol being developed will modify the Forest Service FIA plot design and grid structure. It will consist of long-term vegetation monitoring plots which will measure stand basal area, density of trees, pole trees, saplings, and seedlings, downed woody stems, standing dead, shrub stem density, herbaceous cover, and change in number of shrub stems browsed over time. The protocol used will be a modification of the Forest Service's FIA circular plots. Instead of the four 1/24 acre subplots used by FIA, our modified plots will be a single circular plot with a 10 meter radius. Within this circular plot, there will be several nested square subplots along radii of the circle which will measure pole trees, saplings, and seedlings, as well as the cover and or stem density of dominant herbaceous plants. There may also be herbaceous transects read along the same radii. This plot design will incorporate Brown's fuel transects for measuring litter, duff, 1 hour fuels, 10 hour fuels, 100 hour fuels, and 1000 hour fuels as well as a larger circular plot for measuring standing dead trees.

This design will also allow the NCRN monitoring program to collect information on many parameters of forest structure and composition to provide information on exotic invasive plants in the NCRN, such as change in cover of native and non-native herbaceous plants, change in stem density of shrubs, both native and exotic, stem density and basal area change of native and exotic tree species,.

In addition, the protocol will collect information on several parameters of forest structure and composition that will contribute towards understanding the effects of white-tailed deer on vegetation, such as change in cover of herbaceous plants, stem density of shrubs and number of twigs browsed, and stem density of seedlings, saplings and pole trees.

Principal Investigators and NPS Lead: The P.I. for the protocol development is Dr. David Chojnacky of the Forest Inventory Research, Enterprise Unit. NPS Lead - Mikaila Milton.

Development Schedule, Budget, and Expected Interim Products:
The draft protocol is due by October 1, 2004. The protocol may need additional field testing and refining before network-wide implementation begins. This work will take place in the 2005 field season, with the final report due on October 1, 2005.

Literature Cited:

Cohn, J. 2004. The wildest urban river: Potomac River Gorge. BioScience 54: 8-14.

National Park Service and The Nature Conservancy, Maryland Chapter. 2001. Potomac Gorge site conservation plan. Unpublished report.

National Park Service. 1999. Exotic Plant Management Team, National Capital Region. Unpublished Report.

Randall, J. M. and J. Marinelli. 1996. Invasive plants: weeds of the global garden. Brooklyn Botanic Garden, Handbook 149.

Protocol Development Summary (Last Update: 8/11/04)

Protocol: Occurrence of Selected Invasive Plant Species

Parks Where Protocol will be Implemented: ANTI, CATO, CHOH, GWMP, HAFE, MANA, NACE, PRWI, ROCR, and WOTR

Justification/Issues being addressed:
Invasive non-native plants occur throughout the NCRN and have been identified as high management priorities (NPS 1999). Alien species are considered to be one of the most critical threats to the resources in the Potomac Gorge which is one of the most diverse and rare communities in the country (Cohn 2004, NPS and TNC 2001). In this region, invasive plants are reducing the indigenous biological diversity of the parks, degrading natural landscapes, and disrupting natural ecological processes at many levels.

The known ecological impacts of invasive plants are immense and include loss of threatened and endangered species, altered structure and composition of vegetation communities, and reduction in plant species diversity. In addition, alteration of ecosystem processes occurs, such as the disruption of natural succession, prevention of seedling establishment of native plants, disruption of insect-native plant associations, alteration of natural fire regimes, hybridization with native plant species resulting in altered genomes, and introduction of reservoirs for harmful plant pathogens (NPS 1999, Randall and Marinelli 1996, NPS and TNC 2001).

While long-term changes associated with invasive species are being monitored through other protocols, it is also critical to catch new populations of exotic species early in their invasion of new natural areas. Only when invasions are caught early on will the chance of eradication remain high. This issue is so critical to park management throughout the country that the national Inventory and Monitoring program and the USGS are collaborating on a project that will develop a protocol for the early detection of exotic invasive plants.

Specific Monitoring Questions and Objectives to be Addressed in the Protocol:

The measurable objectives of the protocols are to:

1. Detect presence of target invasive exotic plants in designated ecosystems throughout the region.
2. Quantify the abundance of these populations while the invasive species is rare before it becomes widespread.

Basic Approach:

This protocol will combine adaptive sampling with auxiliary information from habitat models and incidental reports for effective early-detection monitoring of invasive species (Smith et al. 2004). Adaptive sampling is a probability-based sampling design that allows sampling effort to increase in response to observing rare and clustered organisms. Using this method, random points within selected areas will be chosen and searched for invasive populations. If a target invasive is found, a procedure will be implemented to search nearby areas as well. This searching will continue until no new invasive populations of the target species are found and the existing populations are mapped.

Principal Investigators and NPS Lead:
This project is being developed by Smith, Young, and van Manen from the USGS Leetown Science Center in partnership NPS. The NPS lead is Wendy Cass from Shenandoah National Park which will be the test park for this protocol. Upon completion of the protocol and testing at SHEN, the NCRN will examine the possibility of adapting this early detection protocol to NCRN. The NCRN lead is Mikaila Milton.

Development Schedule, Budget, and Expected Interim Products:
The NCRN will adopt and modify a protocol for early detection of invasive plants being developed jointly by the NPS and USGS Leetown Science Center.

Products will include a final report with recommendations, a manuscript in a peer-reviewed journal, conference presentations, and Visual Basic extensions for ArcGIS™ software. One of the products from this research would be the development of a visual basic extension for use with ArcGIS™ software. This GIS-based tool will be available for use by NPS Inventory and Monitoring Program personnel to develop sampling regimes based on incidental observations of newly detected invasive species.

Work Schedule (Smith et al. 2004)

July 04 to Sep 04	Design development, GIS data management, model building,
Oct 04 to Dec 04	Software programming, computer simulation
Jan 05 to June 05	Complete simulations, report writing, software documentation

Budget
The cost of this protocol development is $24,950, which does not include the proposed future development. In addition, the NCRN I & M program will likely have to pay for the adaptation of the finished product and possible pilot testing. The budget for these future tasks have not yet been defined.

Future Developments
After completion of the protocol, the researchers propose to conduct field trials of the sampling protocols based on rare or invasive species. This work would be done with NPS to establish a pilot monitoring program at a chosen national park that follows the proposed protocol. Budgets and work schedules for these additional phases of work have not been developed. The NCRN will contact this research group to initiate the adaptation of early detection methods to this region in the fall of 2004. The expected completion of an early detection protocol for the National Capitol Region Network is fall of 2006.

Literature Cited
Cohn, J. 2004. The wildest urban river: Potomac River Gorge. BioScience 54: 8-14.

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Randall, J. M. and J. Marinelli. 1996. Invasive plants: weeds of the global garden. Brooklyn Botanic
Garden, Handbook 149.
Smith, David, J. Young, and F. van Manan. 2004. GIS-Based Adaptive Sampling for Early-Detection
Monitoring of Invasive Species in National Parks: Incorporating Habitat Models and Incidental
Reports into Sample Selection. Proposal to USGS Status and Trends Program.

Protocol Development Summary (Last Update: 9/15/04)

Protocol: Amphibians

Parks Where Protocol will be Implemented: ANTI, CATO, CHOH, GWMP, HAFE, MANA, MONO, NACE, PRWI, ROCR, and WOTR.

Justification/Issues being addressed:

Amphibian monitoring is a high priority because of their importance as indicators on a world-wide scale. Population declines have been noted by various research projects throughout the world due to disease, introduced predators, loss of habitat, acidification, or ultraviolet-B radiation damage to eggs (Reaser 2000, Flather et al. 1999). The life histories, dispersal abilities and physiological tolerances of this clade of organisms make them potentially more susceptible to environmental change and the introduction of multiple, synergistic stressors at many life history stages (Corn 2000, Sparling et al. 2000, Semlitsch 2003). Because of these characteristics, amphibians may be good indicators of local and regional ecosystem change and perturbation, and many researchers have urged greater attention to this taxon (Semlitsch 2003 and chapters therein). Certain families (e.g., plethodontidae) may be especially valuable indicators in the NCRN (Welsh and Droege 2001).

Though amphibians are being inventoried in most NCRN parks (Gray and Koenen 2001), additional information needs to be collected on available habitats (Pauley, pers. comm.). Also, local population trends are unknown. Population assessments can be coordinated with Amphibian and Reptile Monitoring and Inventory (ARMI) program.

Specific Monitoring Questions and Objectives to be Addressed by the Protocol:

What are the long-term changes in region-wide amphibian species diversity?

The measurable objectives of the protocols are to:

1) Define the present proportion of area occupied for viable amphibian populations within NCRN parks
2) Quantify amphibian species richness among all NCRN parks
3) Establish a sampling framework to detect regional-level decreases to amphibian species richness greater than 10% over 10-year time intervals

Basic Approach:

Recently, the proportion of area occupied (PAO) metric has been developed to aid the U.S. Geological Survey's Amphibian Research and Monitoring Initiative (ARMI) in the collection of large-scale data on amphibians in the United States (MacKenzie et al. 2002, 2003; Bailey et al. 2004, MacKenzie *in press*). This approach is robust to variation in detectability due to species, habitats, and other biotic and abiotic variables. In addition, the model allows the incorporation of covariates to test specific hypotheses about factors influencing the distribution of amphibians while providing methods to estimate occupancy despite missed observations at a site (MacKenzie et al. 2002). The specific objective is to provide spatial and temporal estimates of change in species occupancy within the area of inference, which is defined prior to the initiation of the study and can include individual management areas, parks, or regions.

The PAO methodology will be adapted to the NCRN parks. Results from concurrent monitoring efforts will be integrated with collection of amphibian occupancy data as is feasible, so that hypotheses may be tested with respect to covarying changes in other abiotic and biotic parameters (e.g., water quality, aquatic invertebrates).

Principal Investigators and NPS Lead:

Protocol development will be done through an Inter-Agency Agreement with USGS Patuxent Wildlife Research Center, Laurel Maryland 20708). Principal Investigator will be Robin Jung. NPS I&M Lead: Marcus Koenen.

Development Schedule, Budget, and Expected Interim Products:

Regional- and national-level protocols already exist for the USGS ARMI and NAAMP programs. Protocol development will, however, require field research to identify appropriate habitats for sampling. A pilot project must also be established in 2004 in order to estimate appropriate sample size for long-term monitoring. Draft protocols for the pilot project will be submitted to NPS by February 2005. Field sampling will be conducted February through October 2005. Draft protocols including SOP that meets NPS standards (Oakley et al. 2003) will be submitted to NPS for peer review in December 2005. Final protocols incorporating peer review comments are due January 2006. We have budgeted $51,842 for in FY 2004 for protocol development and testing.

Literature Cited:

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Sparling DW, Linder G and Bishop CA. 2000. Ecotoxicology of amphibians and reptiles. Pensacola, FL: SETAC Press.
Welsh, H. and S. Droege. 2001. A case for using plethodontid salamanders for monitoring biodiversity and ecosystem integrity of North American forests. Cons. Bio. 15: 558-569.

Protocol Development Summary (Last Update: 8/18/04)

Protocol: Grassland and Forest Bird Communities

Parks Where Protocol will be Implemented: Grassland bird communities at: ANTI, MANA, MONO. Forest Bird Communities at: CATO, CHOH, GWMP, HAFE, NACE, PRWI, ROCR, and WOTR.

Justification/Issues being addressed:
The region around the NCRN parks provides habitat for a high diversity of avian species. Biological inventories also indicate that the parks host a variety of species of conservation concern including grassland and forest species (Sinclair et al. 2003, Brewer 2001). Previous studies in the region also show that the urban landscape in and around Washington including the downtown parks (eg. ROCR, NACC), provides diverse habitats that hosts nearly as many species as the surrounding suburbs (Hadidian et al. 1997).

The use of birds as ecological indicators has been questioned because determining the effect of environmental changes on bird populations is very difficult given the myriad of factors that can cause population changes (Temple and Wiens 1989, Morrison 1986). Monitoring bird populations, however, is important in order to determine if viable populations exist in the parks (Temple and Wiens 1989).

Key reasons for monitoring birds in network parks are that they are protected under the (1) Migratory Bird Treaty Act and (2) The Migratory Bird Executive Order signed by President Bill Clinton in 2000, In addition, birds represent a popular taxanomic group that can be readily sampled and comparable regional and national datasets exist including the Breeding Bird Surveys (BBS) and the Christmas Bird Counts (CBC) already exist.

Specific Monitoring Questions and Objectives to be Addressed by the Protocol:
Some of the specific monitoring questions that will be addressed by this protocol include:

- What are the long-term trends in species composition and abundance of the grassland and forest bird communities?
- What is the natural level of variation in population distribution and abundance of the forest bird communities?
- What is the productivity of selected forest species in the parks relative to other reference areas?
- Are the NCRN parks host to source or sink population?
- How do management activities affect the composition and abundance of grassland or forest bird species?

The measurable objectives of the protocols are to:

1. Determine annual changes in species composition and abundance of birds in grassland and forested communities.
2. Estimate reproductive success for birds in forest communities

3. Estimate annual survival for birds in forest communities.

Basic Approach:

Several ongoing monitoring programs in the NCRN will be evaluated for their effectiveness to meet all or some of the listed objectives including the Breeding Bird and Mid-Winter Bird Counts at CHOH; Breeding Bird Survey at PRWI; and the Breeding Bird Survey at Dyke Marsh of the GWMP. Additional standard monitoring protocols exist including point count surveys (VCP distance sampling), mist-netting and banding (MAPS protocol), nest searching and monitoring (BBIRD protocol) and may be added to complete coverage. In addition, specialized surveys may need to be considered for monitoring taxa not included in standard research (i.e. nocturnal) or for taxa with specialized habitat. Monitoring Avian Productivity and Survivorship (MAPS) have already been established at Fort Belvoir in Fairfax County (Nott et al. 2002) and may also be useful to evaluate and monitor resource management in the NCRN. Data should be consolidated with National Point Count database if appropriate.

Principal Investigators and NPS Lead:

Forest bird protocols will be developed through an Inter-Agency Agreement with USGS (Patuxent Wildlife Research Center, Laurel Maryland 20708). Principal Investigators is Deanna Dawson. NPS I&M Lead: Marcus Koenen. Grassland bird protocols are being developed through a multi-network Inter-Agency Agreement with USGS (Patuxent Wildlife Research Center, Laurel Maryland 20708). Principal Investigators is Bruce Peterjohn. NPS I&M Lead: Jim Comiskey – Mid-Atlantic Network.

Development Schedule, Budget, and Expected Interim Products:

Regional- and national-level protocols already exist for the MAPS and BBIRD programs and for distance sampling using variable circular plot counts. Therefore, protocol development will not require field research and will consist primarily of writing a protocol that meets NPS standards (Oakley et al. 2003) and incorporates existing standard protocols. We will need to write new sections in the protocol narrative and SOPs to make the standard protocols specific to NCRN parks, such as describing sampling locations and documenting how data will be entered into NPS computers, analyzed, and reported. The P.I.'s will produce a draft protocol ready for external peer review by December 1, 2004. After peer review, revision and approval, we hope to implement the protocol in Spring 2005. We have budgeted $40,525.00 for in FY 2004 for protocol development and testing.

<u>Literature Cited</u>:

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Oakley, K., L. Thomas, and S. Fancy. 2003. Guidelines for long-term monitoring protocols. Wildlife Society Bull. 31:1-3.
Sinclair, J., Koenen, Sybil Hood, Mikaila Milton, and Christina Wright. 2003. Avian Inventory at Six National Capital Region National Parks. National Park Service. National Capital Region Network, Inventory and Monitoring Program. Final Report.
Temple, S. and J. Wiens. 1989. Bird populations and environmental changes: can birds be bioindicators? American Birds 43: 260-270.

Protocol Development Summary (Last Update: 8/11/04)

Protocol: White-tailed Deer

Parks Where Protocol will be Implemented: ANTI, CATO, CHOH, GWMP, HAFE, MANA, MONO, NACE, PRWI, ROCR, and WOTR.

Justification/Issues being addressed:
The number of deer are increasing nationally and have significant ecological and economic impacts on the region (Flather et al. 1999). In many areas they are considered overabundant (Flather et al 1999). Deer ranked as a high priority for monitoring in this network because of their significant impacts on the spread of exotic species, prevention of tree regeneration, and impacts to small mammal, amphibian, and bird populations. In addition, the number of car collisions with deer have increased dramatically during the last 20 years (Flather et al. 1999) and are a concern especially in parks that have commuter routes running through or adjacent to the parks including CHOH, GWMP, MONO, NACE, and ROCR. Preliminary results from a pilot deer density monitoring program indicate that deer in the NCRN range from 12 deer/km^2 (PRWI) to 38 deer/km^2 (CATO) (Bates, pers. comm.). The key reason for monitoring deer in NCRN is that data are needed to support development of Environmental Impact Statements for management activities.

Specific Monitoring Questions and Objectives to be Addressed by the Protocol:

Some of the specific monitoring questions that will be addressed by this protocol include:

- What are the long-term trends in deer abundance in NCRN parks?
- What is the natural level of variation in population abundance?
- Are long-term changes in deer abundance correlated with long-term changes in vegetation and/or bird populations?.

The measurable objectives of the protocols are to:

1. Determine annual changes in deer abundance at each NCRN Park.
2. Correlate deer abundance with Forest Health Indicators (See Protocol: Forest Health) to evaluate effects of deer on vegetation.

Basic Approach:
The NCRN has a history of monitoring deer using an established, field-tested protocol developed by Dr. Brian Underwood (SUNY, Ithaca, N, 13210) that uses distance estimation procedures. The protocols will be written by the NCR – Regional Wildlife Biologist in order to meet NPS guidelines (Oakley et al. 2003).

Principal Investigators and NPS Lead: Protocol development will be completed by the NCR Regional Wildlife Biologist Scott Bates. NPS I&M Lead: Marcus Koenen.

Development Schedule, Budget, and Expected Interim Products:

Distance sampling has been conducted since 2001 and protocol development will not require field research. Work will consist primarily of revising an existing, peer-reviewed and field-tested protocol to meet NPS standards (Oakley et al. 2003). We will need to write new sections in the protocol narrative and SOPs to make the standard protocols specific to NCRN parks, such as describing sampling locations and documenting how data will be entered into NPS computers, analyzed, and reported. The Regional Wildlife Biologist will produce a draft protocol ready for external peer review by May 30, 2004. After peer review, revision and approval, we hope to implement the protocol in Spring 2005.

Literature Cited

Flather, S. Brady, and M. Knowles. 1999. Wildife resource trends in the United States. USDA Forest Service, RMRS-GTR-33.

Oakley, K., L. Thomas, and S. Fancy. 2003. Guidelines for long-term monitoring protocols. Wildlife Society Bull. 31:1-3.

Protocol Development Summary (Last Update: 9/7/04)

Protocol: Rare, Threatened, and Endangered (RTE) Species

Parks Where Protocol will be Implemented: ANTI, CATO, CHOH, GWMP, HAFE, MANA, MONO, NACE, PRWI, and ROCR.

Justification/Issues being addressed:
National Parks are required under law to protect federally listed threatened and endangered species. Policy directs NPS to protect state listed species as much as possible (DO-77-8 Section 3.1 and 3.2; NPS 2002). The RTE workgroup of the NCRN Science Advisory Committee developed criteria to prioritize species reflecting legal protection and guidance based on heritage ranks (NatureServe 2002). Ten of the 11 NCRN parks have identified RTE species with viable populations. Monitoring these populations is a high priority for the parks given their legal and policy mandates.

Seven of the 11 NCRN parks contain sites with viable populations of multiple RTE Species (ANTI, CHOH, GWMP, MANA, NACE, PRWI, and ROCR). Monitoring these sites is an efficient way to ensure that priority species are conserved. This site based conservation is based on an approach similar to one developed by the Heritage Programs and The Nature Conservancy (The Nature Conservancy 2000, Poiani et al. 1998). In some cases, however, RTE species were not located at a priority site or they have species specific monitoring needs and individual protocols will need to be developed.

Specific Monitoring Questions and Objectives to be Addressed by the Protocol:

Some of the specific monitoring questions that will be addressed by this protocol include:

- What is the population status of RTE species in NCRN parks?
- What are the main threats (e.g. exotic species, deer browse, visitor impacts) to the RTE sites and species.
- What are the triggers for management actions?

The measurable objectives of the protocols are to:

1. Determine annual changes in abundance of RTE species.
2. Predict viability of RTE species.
3. Investigate RTE species - habitat relationships and how they potentially relate to threats such as exotic species invasion, deer herbivory, or visitor impacts.
4. Understand and predict how RTE Species populations may change and identify appropriate management activities.

Basic Approach:
Monitoring sites with multiple RTE species is more efficient than monitoring each RTE Species individually. Those species that do not fall within specific sites but are still considered a top priority because of legal or policy priorities will be monitored individually. The PI will be identifying which sites can be effectively monitored and

how monitoring should be conducted at the site. In addition, the PI will be identifying which species fall outside of the Priority Sites and will develop appropriate species specific monitoring strategies.

Principal Investigators and NPS Lead:

Protocols are being developed by Virginia Polytechnic Institute, Blacksburg, Virginia, 24061. Principal Investigators will be Jeff Waldon and Dr. Allison Wells. NPS I&M Lead: Marcus Koenen.

Development Schedule, Budget, and Expected Interim Products:

RTE data is maintained by NPS and State Heritage Programs. Protocol development will include only limited field work and will consist primarily of writing a protocol that meets NPS standards (Oakley et al. 2003). We will need to write new sections in the protocol narrative and SOPs to make the standard protocols specific to NCRN parks, such as describing sampling locations and documenting how data will be entered into NPS computers, analyzed, and reported. The P.I.'s will produce a draft protocol ready for external peer review by December 1, 2004. After peer review, revision and approval, we hope to implement the protocol in Spring 2005. We have budgeted $80,000 from FY 2003 for protocol development and testing.

<u>Literature Cited</u>:

NatureServe. 2002. BCD database for Maryland, Virginia, Washington DC, and West Virginia.

Poiani, K. A., J. V. Baumgartner, S. C. Buttrick, S. L. Green, E. Hopkins, G. D. Ivey, K. P. Seaton, and R. D. Suttor. 1998. A scale-independent, site conservation planning framework in The Nature Conservancy. Landscape and Urban Planning 43: 143-156.

Oakley, K., L. Thomas, and S. Fancy. 2003. Guidelines for long-term monitoring protocols. Wildlife Society Bull. 31:1-3.

The Nature Conservancy. 2000. The five-s framework for site conservation: a practitioner's handbook for site conservation planning and measuring conservation success. The Nature Conservancy. Vol 1. Second Ediction.

Protocol Development Summary (Last Update 9/8/04)

Protocol: Pests

Parks Where Protocol will be Implemented: CATO, CHOH, GWMP, HAFE, MANA, MONO, NACE, PRWI, ROCR, and WOTR.

Justification/Issues being addressed:

Despite over 100 years of presence in North America, researchers are still at a loss to explain and predict the extent of the changes in forest vegetation likely to take place through gypsy moth (*Lymantria dispar*) disturbance. A major concern is the potential loss of economically and ecologically dominant oak (*Quercus*) and other host species. Most studies of forest compositional changes with gypsy moth defoliation indicate that less susceptible species will dominate the forest. Because the gypsy moth has many undesirable effects on trees and forests, efforts are made to manage the problem. "Eradication" and "Slow the Spread" are methods used by the USDA Forest Service to prevent or postpone the establishment of gypsy moth populations in portions of the country where it currently does not exist. . Suppression, silviculture, and biological control are methods used to manage established gypsy moth populations. Mapping outbreaks and conducting egg mass surveys are essential component of any management efforts (USDA 2004a).

The National Capital Region Center for Urban Ecology has been working with the U.S. Forest Service and the D.C., Maryland and Virginia Departments of Agriculture since 1980 to monitor gypsy moth populations, map infestations, determine treatment threashholds and implement various control measures. Management of gypsy moth outbreaks in NCRN using pesticides began in 1982 with the aerial application of *Bacillus thuringiensis* var. *kurstaki* to over 5000 acres at Catoctin Mountain Park (CATO). NCRN parks with significant oak forest that participate in gypsy moth monitoring and treatment include CATO, CHOH, GWMP, HAFE, MANA, MONO, NACE, PRWI, ROCR and WOTR (USDA. 2004b).

Treatment options for gypsy moth have evolved over the decades from entirely synthetic chemical products with sometimes large potential environmental impacts to somewhat more biological and environmentally considerate products. The Forest Service's Environmental Impact Statement for gypsy moth management (USDA 1995) (identified three approved treatment options for gypsy moth, namely *Bacillus thuringiensis kurstaki* (*B.t.k.*), nucleopolyhedrosis virus (Gypchek), and diflubenzuron (Dimilin). B.t.k. is a naturally occurring bacteria that potentially affects all members of the insect Order Lepidoptera (butterflies and moths) and likely affects many native species when applied operationally. Gypchek is the gypsy moth-specific product made by the Forest Service from caterpillars infected with a naturally occurring virus. Both of these products have relatively short activity times (1-2 weeks). Dimilin is a non-specific, long lasting residual synthetic chemical insecticide that potentially affects many groups of arthropods. It acts by interfering with molting and chitin synthesis characteristic of most invertebrates.

Long-term impacts from Gypsy moths may be derived from monitoring vegetation communities at various scales (see Protocol Forest Health Monitoring and Protocol Development Summary for Land Cover for details).

Specific Monitoring Questions and Objectives to be Addressed by the Protocol:

- What is the status of Gypsy Moths infestations at NCRN parks?
- When are management actions needed?
- What are the long-term ecological impacts of gypsy moth infestations?

The measurable objectives of the protocols are to:

1. Determine annual egg mass abundance at potential infestation sites.
2. Map areas of infestation, annually

Basic Approach:
Protocols for Gypsy Moth egg mass surveys and aerial mapping have been developed by the USDA Forest Service (USDA 2004a). In order to correlate gypsy moth impacts, data can be correlated with Forest Health Monitoring Protocols (See Protocol Development Summary – Forest Health Monitoring) and remote sensing (See Protocol Development Summary – Land Cover).

Principal Investigators and NPS Lead:
NPS IPM Lead: Jil Swearingen. NPS I&M Lead: Marcus Koenen.

Development Schedule, Budget, and Expected Interim Products:
Protocol development will consist primarily of writing a protocol that meets NPS standards (Oakley et al. 2003) and incorporates existing standard protocols. We will need to write new sections in the protocol narrative and SOPs to make the standard protocols specific to NCRN parks, such documenting how data will be entered into NPS computers, analyzed, and reported. The NPS I&M Lead will produce a draft protocol ready for external peer review by June 1, 2005. After peer review, revision and approval, we hope to implement the protocol in Spring 2006.

Literature Cited:

Oakley, K., L. Thomas, and S. Fancy. 2003. Guidelines for long-term monitoring protocols. Wildlife Society Bull. 31:1-3.

USDA. 2004a. Gypsy Moth in North America. Available Online Sept. 2004: http://www.fs.fed.us/ne/morgantown/4557/gmoth/.

USDA. 2004b. Gypsy Moth Suppression Project Summaries. Available Online Sept. 2004: http://na.fs.fed.us/wv/gmdigest.

USDA. 1995. Gypsy Moth Management in the United States: A Cooperative Approach. Final Environmental Impact Statement. Nov. 1995.

Protocol Development Summary (Last Update: 9/15/04)

Protocol: Shoreline Features

Parks Where Protocol will be Implemented: CHOH, GWMP, and NACE.

Justification/Issues being addressed:
Quantifying shorelines changes is an important consequence of monitoring global climate change. Sedimentation and depositional patterns that result from increasing agricultural practices and urban development can impact shoreline conformity, thereby altering inputs to tidal marshes. Several parks in the NCRN have important wetlands in the tidal Potomac especially Dyke Marsh in the GWMP. This is the largest remaining freshwater marsh in the DC area. Other important marsh habitats are found at Piscataway and at Kenilworth Aquatic Gardens of NACE. Marsh area is being rapidly loss and restoration activities have ongoing at Kenilworth and are intensively monitored by USGS. Shoreline monitoring is required to document the rate and extent of tidal marsh loss.

Specific Monitoring Questions and Objectives to be Addressed in the Protocol:
- How much shoreline including wetlands is being lost or gained?

The measurable objectives of the protocols are to:
1. To document the amount of land area being gained or lost annually in the tidal portions of the Potomac and Anacostia Rivers.
2. To document land area conversion of emergent tidal wetlands of Anderson level 2 classification using spectral analysis and remote sensing techniques.

Basic Approach:
The protocols will use data from multiple sensors, including aerial photography, IKONOS satellite imagery, and Landsat ETM+ imagery. A multi-scale approach that facilitates the acquisition of fine scale data suitable for detailed analyses of small areas (1-m resolution or smaller) and coarser data (e.g., up to 15-m resolution) for repeat characterization of larger areas is recommended. A pilot program will test effectiveness of remote sensing protocols for the National Capital Region Network park units. An implementation plan will be developed that balances the costs of repeated image acquisition, the production of high quality maps for monitoring a broad-range of Park resources, and the estimation of uncertainties of decisions based on these protocols.

Principal Investigators and NPS Lead:
Protocol development will be done through the University of Maryland Center for Environmental Sciences (UMCES) which is part of the Chesapeake Watershed Cooperative Ecosystem Studies Unit (CESU). The Principal Investigators will be Phil Townsend and Bob Gardner. NPS I&M Lead: Shawn Carter.

Development Schedule, Budget, and Expected Interim Products:
Protocol development was initiated in FY2003 when $150,000 was set aside for the project with the CESU. Protocols including SOP on park specific scale resolution, data

acquisition, interpretation of spatial data, and data storage will follow NPS guidelines (Oakley et al. 2003). The project is being pursued in four phases:

Phase 1: January-June, 2004: All literature reviews will be completed, test data and software will be acquired and preliminary protocols developed. Meetings with NPS personnel will identify and address specific interests and concerns.

Phase 2: July-December, 2004: Formal protocol development will be undertaken and pilot studies will be designed and implemented (with appropriate NPS or peer review).

Phase 3: January-June 2005: Pilot studies will be completed and evaluated (including field visits). Protocols will be written up and submitted for preliminary evaluation by NPS.

Phase 4: July-December 2005: Protocols will be finalized and all formal documentation developed.

<u>Literature Cited</u>:

Oakley, K., L. Thomas, and S. Fancy. 2003. Guidelines for long-term monitoring protocols. Wildlife Society Bull. 31:1-3.

Protocol Development Summary (Last Update: 9/15/04)

Protocol: Land Cover

Parks Where Protocol will be Implemented: ANTI, CATO, CHOH, GWMP, HAFE, MANA, NACE, PRWI, ROCR, and WOTR.

Justification/Issues being addressed:
Habitat fragmentation has been associated with a variety of negative consequences to birds herpetofauna, wildlife, and vegetation communities (Wilcove et al. 1986, Yahner and Scott 1988). Fragmentation also provides the opportunity for invasion of exotic or undesirable species. Selecting an adequate scale at which to evaluate the effects of fragmentation, however, is difficult without first identifying what is being managed (e.g. what species or processes; Beatley et al. 2003) and the scales of disturbance to which those species/processes respond. Ultimately, multiple scales that apply to multiple taxa must be considered. Small-scale vegetation changes are addressed other protocols (See Protocols: Forest Health Monitoring or Protocols: Occurrence of Selected Invasive Plant Species). In contrast, this protocol addresses the broad scale to evaluate habitats within a regional context to facilitate prioritization of management projects. The Lower Chesapeake Bay Watershed was suggested as a large scale because of the wealth of data already available from EPA and pother sources (Jones et al. 1997). A variety of landscape level indices can be calculated at various scales including size / edge index, fragmentation, edge ratios, patch sizes, cover type proportions, habitat connectivity/heterogeneity, etc. (Wilcove et al. 1986).

Specific Monitoring Questions and Objectives to be Addressed in the Protocol:

- What are the changes in area and extent of dominant NCRN vegetative communities?

The measurable objectives of the protocols are to:

1) Changes to Anderson level 2 cover types based on indices characterizing: proportion of area, edge-to-interior ratios, cover type shape, and landscape context.

Basic Approach:
The protocols will use data from multiple sensors, including aerial photographs, IKONOS satellite imagery, and Landsat ETM+ imagery. A multi-scale approach that facilitates the acquisition of fine scale data suitable for detailed analyses of small areas (1-m resolution or smaller) and coarser data (e.g., up to 15-m resolution) for repeat characterization of larger areas is recommended. A pilot program will test effectiveness of remote sensing protocols for the National Capital Region Network park units. An implementation plan will be developed that balances the costs of repeated image acquisition, the production of high quality maps for monitoring a broad-range of Park resources, and the estimation of uncertainties of decisions based on these protocols.

Principal Investigators and NPS Lead:

Protocol development is being undertaken by the University of Maryland Center for Environmental Sciences (UMCES) which is part of the Chesapeake Watershed Cooperative Ecosystem Studies Unit (CESU). The Principal Investigators are Phil Townsend and Bob Gardner. NPS I&M Lead: Shawn Carter.

Development Schedule, Budget, and Expected Interim Products:

Protocol development was initiated in FY2003 when $150,000 was set aside for the project with the CESU. Protocols including SOP on park specific scale resolution, data acquisition, interpretation of spatial data, and data storage will follow NPS guidelines (Oakley et al. 2003). The project is being pursued in four phases:

Phase 1: January-June, 2004: All literature reviews will be completed, test data and software will be acquired and preliminary protocols developed. Meetings with NPS personnel will identify and address specific interests and concerns.

Phase 2: July-December, 2004: Formal protocol development will be undertaken and pilot studies will be designed and implemented (with appropriate NPS or peer review).

Phase 3: January-June 2005: Pilot studies will be completed and evaluated (including field visits). Protocols will be written up and submitted for preliminary evaluation by NPS.

Phase 4: July-December 2005: Protocols will be finalized and all formal documentation developed.

<u>Literature Cited</u>:

Beatley, T., C. Duerksen, R. Knight, and B. Stein. 2003. Conservation thresholds for land use planners. Environmental Law Institute.

Jones, B., K. Ritters, J. Wickham, R. Tankersley, R. O'Neill, D. Chaloud, E. Smith, and A. Neale. 1997. An ecological assessment of the United States Mid-Atlantic Region: A landscape atlas. EPA/600/R-97/130.

Oakley, K., L. Thomas, and S. Fancy. 2003. Guidelines for long-term monitoring protocols. Wildlife Society Bull. 31:1-3.

Wilcove, D.S., C.H. McLellan, and A.P. Dobson. 1986. Habitat fragmentation in the temperate zone, pp. 237–256. In M.E. Soulé (ed.), Conservation biology: The science of scarcity and diversity. Sunderland, MA: Sinauer Associates.

Yahner, R. H. and D. P. Scott. Effects of forest fragmentation on depredation of artificial nests. J. Wildl. Management 52: 158-181.

Protocol Development Summary (Last Update: 9/15/04)

Protocol: Landscape Condition

Parks Where Protocol will be Implemented: ANTI, CATO, CHOH, GWMP, HAFE, MANA, NACE, PRWI, ROCR, and WOTR.

Justification/Issues being addressed:
Habitat fragmentation has been associated with a variety of negative consequences to birds herpetiles, wildlife, and vegetation communities (Wilcove et al. 1986, Yahner and Scott 1988). Fragmentation also provides the opportunity for invasion of exotic or undesirable species. Selecting an adequate scale at which to evaluate the effects of fragmentation, however, is difficult without first identifying what is being managed (e.g. what species or processes; Beatley et al. 2003) and the scales of disturbance to which those species/processes respond. Ultimately, multiple scales that apply to multiple taxa must be considered. Small-scale vegetation changes are addressed other protocols (See Protocols: Forest Health Monitoring or Protocols: Occurrence of Selected Invasive Plant Species). In contrast, this protocol addresses the broad scale to evaluate habitats within a regional context to facilitate prioritization of management projects. The Lower Chesapeake Bay Watershed was suggested as a large scale because of the wealth of data already available from EPA and pother sources (Jones et al. 1997). A variety of landscape level indices can be calculated at various scales including size / edge index, fragmentation, edge ratios, patch sizes, cover type proportions, habitat connectivity/heterogeneity, etc. (Wilcove et al. 1986).

Specific Monitoring Questions and Objectives to be Addressed in the Protocol:
- What is the rate of loss or degradation of dominant NCRN cover types?

The measurable objectives of the protocols are to:
1) Detect between-class changes (conversion from one cover type to another) or within-class changes (transformation in cover condition).
2) Determine rates of degredation or outright loss of Anderson level 2 cover types within NCRN parks.

Basic Approach:
The protocols will use data from multiple sensors, including aerial photographs, IKONOS satellite imagery, and Landsat ETM+ imagery. A multi-scale approach that facilitates the acquisition of fine scale data suitable for detailed analyses of small areas (1-m resolution or smaller) and coarser data (e.g., up to 15-m resolution) for repeat characterization of larger areas is recommended. A pilot program will test effectiveness of remote sensing protocols for the National Capital Region Network park units. An implementation plan will be developed that balances the costs of repeated image acquisition, the production of high quality maps for monitoring a broad-range of Park resources, and the estimation of uncertainties of decisions based on these protocols.

Principal Investigators and NPS Lead:
Protocol development is being led by the University of Maryland Center for Environmental Sciences (UMCES) which is part of the Chesapeake Watershed Cooperative Ecosystem Studies Unit (CESU). The Principal Investigators are Phil Townsend and Bob Gardner. NPS I&M Lead: Shawn Carter.

Development Schedule, Budget, and Expected Interim Products:
Protocol development was initiated in FY2003 when $150,000 was set aside for the project with the CESU. Protocols including SOP on park specific scale resolution, data acquisition, interpretation of spatial data, and data storage will follow NPS guidelines (Oakley et al. 2003). The project is being pursued in four phases:

Phase 1: January-June, 2004: All literature reviews will be completed, test data and software will be acquired and preliminary protocols developed. Meetings with NPS personnel will identify and address specific interests and concerns.

Phase 2: July-December, 2004: Formal protocol development will be undertaken and pilot studies will be designed and implemented (with appropriate NPS or peer review).

Phase 3: January-June 2005: Pilot studies will be completed and evaluated (including field visits). Protocols will be written up and submitted for preliminary evaluation by NPS.

Phase 4: July-December 2005: Protocols will be finalized and all formal documentation developed.

<u>Literature Cited</u>:

Beatley, T., C. Duerksen, R. Knight, and B. Stein. 2003. Conservation thresholds for land use planners. Environmental Law Institute.

Jones, B., K. Ritters, J. Wickham, R. Tankersley, R. O'Neill, D. Chaloud, E. Smith, and A. Neale. 1997. An ecological assessment of the United States Mid-Atlantic Region: A landscape atlas. EPA/600/R-97/130.

Oakley, K., L. Thomas, and S. Fancy. 2003. Guidelines for long-term monitoring protocols. Wildlife Society Bull. 31:1-3.

Wilcove, D.S., C.H. McLellan, and A.P. Dobson. 1986. Habitat fragmentation in the temperate zone, pp. 237–256. In M.E. Soulé (ed.), Conservation biology: The science of scarcity and diversity. Sunderland, MA: Sinauer Associates.

Yahner, R. H. and D. P. Scott. Effects of forest fragmentation on depredation of artificial nests. J. Wildl. Management 52: 158-181.